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## Quarterly Technical Summary

## Advanced Electronic Technology

15 August 1975

Prepared for the Department of the Air Force  
under Electronic Systems Division Contract F19628-76-C-0002 by

### Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LEXINGTON, MASSACHUSETTS



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MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT  
TO THE  
AIR FORCE SYSTEMS COMMAND

1 MAY - 31 JULY 1975

ISSUED 24 SEPTEMBER 1975

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## INTRODUCTION

This Quarterly Technical Summary covers the period 1 May through 31 July 1975. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

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DATA SYSTEMS  
DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 May through 31 July 1975 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs:

Seismic Discrimination	ARPA
Educational Technology	AF, NSF, Bureau of Mines
Speech Evaluation	OSD - DCA
Digital Voice Terminal	ESD
Packet Speech	ARPA
Airborne Command and Control	ARPA
Incoherent Scatter	NSF
Radar Propagation Studies	BMDATC
Radar Signal Processing Technology	BMDATC

M. A. Herlin  
Head, Division 2

I. L. Lebow  
Associate Head

## DIGITAL COMPUTERS

### GROUP 23

#### I. INTRODUCTION

The principal effort this quarter has been in evaluation and possible process improvements of the universal array. One perfect multiplier was made and delay measurements are reported.

#### II. APPLICATIONS

##### A. Quantizers

To determine whether our three-bit quantizer could be operated at less power in lower speed converters, devices were fabricated with power dissipation reduced from 900 to 450 mW by increasing resistor sheet resistance by a factor of two. The most strongly affected performance parameter is analog-input slew rate, which drops to a typical value of 1 V/nsec, compared to 2 V/nsec for the full-power circuit. Other indicators of circuit speed change less: small-signal rise time increases from 0.8 to 1.1 nsec, the width of unlatch pulse for 2 mV hysteresis increases from 1.5 to 2 nsec, and significant changes (1 mV) in comparator offset begin as the unlatch pulse is reduced below 7 nsec, compared to 5 nsec. Comparator precision is perhaps slightly improved.

The experimental 6-bit A/D converter which has been operated at 200 MS/sec is being upgraded by addition of high-speed logic on the output.

##### B. $4 \times 4$ Multiplier

One  $4 \times 4$ -bit multiplier universal array chip passed all function tests at the wafer probe and was successfully packaged in a 40-pin DIP. The delay along the slowest path in the multiplier is 15 nsec for one transition and 20 nsec for the other. The longer delay is dependent on internal pulldown resistor values which can perhaps be decreased. The delay along the carry path is 5 nsec. Delays through the latches have not been determined yet. The one successful chip verifies that the logic design and layout are correct.

The 40-pin DIP is not a satisfactory package because of its large size, high-resistance leads, and incompatibility with good heat sinking. For some designs it may not have enough leads. Flat packs with 50 and 64 leads are being considered. In cooperation with Group 87, a hybrid package is being designed for a  $4 \times 16$  multiplier which would include four multiplier chips and one control chip. The principal problems will be high heat dissipation (~15 watts) and the large number of wire bonds on the hybrid substrate.

##### C. New Designs

Two new logic designs using the gate array have been completed and interconnect masks are being made. The first is a control chip for sequencing the 4-bit inputs to the array multiplier and collecting the outputs. The second design is a general-purpose programmed sequencer for providing the clock control to the DVT or other digital processors.

A digital-to-analog converter circuit has been designed for possible use in high-frequency radar waveform generation.

### III. INTEGRATED CIRCUIT PROCESSING

#### A. ECL Universal Array

The universal array chip is  $0.238 \times 0.253$  inch large, about six times larger in area than the quantizer chip so considerable process improvement is expected to be necessary. Only one good chip has been produced from the first 27 wafers which have reached wafer probe. One problem which has been identified is metal-to-metal via resistance due to low deposition temperature of second-level metal. In addition, the unusually severe humidity conditions during July are thought to have caused significant degradation in photoresist adhesion.

#### B. Oxide Isolation

Development of an oxide isolation scheme has been continued on a limited basis, with chief emphasis being placed on limiting the growth of surface bumps which could interfere with photolithography.

### IV. DESIGN AND TESTING

#### A. Chip Probing

In order to obtain more diagnostic information, a prober has been built to permit manual probing of 2nd-level metal on the universal array. The standard probe card contacts the peripheral pads, and two precision manual probes will be available to probe the 0.6-mil-wide conductors.

#### B. Transistor Testing

All transistor test programs have been transferred from the TX-2 computer to our mini-computer. At the same time, the  $f_T$  test was made computer controlled which permits the generation of linear, log, and semilog plots as well as the computation of  $f_{Tmax}$  and  $C_{TE} + C_{TC}$ .

A Hewlett Packard 8542 network analyzer has been used to measure s parameters of our transistors. Some small equipment modifications are required. Comparison will be made with measurements from our equipment and possible advantages assessed.

#### C. Process Simulation

The process simulation program has been transferred to the 370 computer. Concentration dependent diffusion coefficients, which are essential, have yet to be included.



PROCESSOR AND EDUCATION TECHNOLOGY  
GROUP 27

AFCS MAINTENANCE TRAINING SYSTEM

Previous reports on this project were carried in the Education Technology Program QTS. Other projects in that Program are now reported directly to their - non-military - sponsors.

Earlier work carried out on this Program has resulted in the construction and delivery, to the 5th Mobile Communications Group at Robins AFB, of one LTS-3S terminal. In addition, approximately 14 hours of instructional material have been developed, including several hours of Career Development (CDC) material which was produced by personnel of the School for Applied Aerospace Science, Air Technical Training Command, Keesler AFB. All of the material concerns performance measurements and maintenance of an AN/TRC-97A mobile communication set, a 24-channel microwave system which may be operated LOS or tropo-scatter. The present program is directed at evaluation of the Lincoln Terminal System (LTS) as a job performance aid, a source of on-the-job training, and a tool for maintenance management in an operational environment.

During the past quarter, several 3-level personnel and several experienced technicians have carried out maintenance procedures on the TRC-97A using the LTS. This has been done in preparation for a more formal test and evaluation to be conducted in the next quarter.

As had been observed in earlier trials, these men could perform adequately under machine guidance. Some remaining deficiencies in the support material were uncovered; primarily ambiguities in description and lack of detailed instruction in the use of test equipment. We have corrected most of these deficiencies and are preparing material on the use of test equipment.

A retired NCO, formerly with the 5th MOB, has been hired to conduct future testing and evaluation. He is a qualified TRC-97A crewman, and can act as safety monitor and offer guidance and troubleshooting if necessary. In addition, he is being trained to perform LTS-3S maintenance.

Current plans are to have each 3-level spend two days as a subject. The first morning he will be introduced to the LTS, be given a brief explanation of the role of the TRC-97A, and become familiar with the van. He will then proceed through the six modules of CDC material. In the afternoon, he will receive an explanation of the importance of the SCOPE CREEK performance measurements and perform, under the guidance of LTS, the MUX LOOP, Synthesizer, Receiver Noise, and RF LOOP performance measurements. On the following days, he will perform these same measurements twice again.

Records will be kept of time required, errors made, and the amount of supervisory intervention required. If these figures decrease, as we expect them to, we will consider carrying some individuals through to a "fully trained" status. In the meantime, we will, of course, be recording qualitative observations for system improvements and as a basis for assessing its acceptability by operational personnel.

## COMPUTER SYSTEMS

### GROUP 28

Hardware changes and benchmark tests preparatory to an operating system change summarize the work of the past quarter. The main memory of the Laboratory's IBM 370/168 computer system has been increased, and a second swapping disk has been installed. Together these changes will increase efficiency and accommodate more users with greater storage requirements.

The computer is most efficient when all its semi-independent subsystems are kept busy in parallel. This is done by concurrently executing several different programs each of whose tasks at that moment occupy one of the subsystems. While one is writing data to a tape, another might be reading data from a disk, a third performing arithmetic operations on the central processor, and so on. The more programs that can be loaded into main memory ready for execution, the greater the likelihood that all parts of the system can be kept busy. However, besides design limits on the size of main memory there is an economic limit. Through the continuing use of performance monitoring facilities it was determined that more main storage would produce greater efficiency. One million bytes (8 binary digits) have been added for a total of three million. Early results confirm performance improvement.

A companion problem to the size of the real main storage is the collective size of user working space. Seventy or more users, occupying several hundred thousand bytes of storage each, cannot coexist in a real main memory of only three million bytes. It can be effected by the mechanism of paging. Over short intervals of execution only a few small portions (pages) of a user's program or data are needed in main storage. When not required the unused pages are stored on a swapping disk. Recent increases in both the number of users and the size of individual working space have caused overflow of the single swapping disk to slower disks. The extra time required to move pages into and out of main memory from the slow disks delays processing and reduces efficiency. A second swapping disk was installed during the quarter to accommodate this greater demand and maintain performance efficiency.

Laboratory programmers have a choice of two different operating systems. VM/370 provides interactive facilities during normal working hours when most users are present and require immediate response. VS2 provides batch processing services during evening hours for longer running jobs that generally do not require an immediate interactive response. By their inherent designs this scheduling of systems would seem to be manifest. But a problem arises in the definition of such things as "immediate response." The resulting operating rules are likely to be framed in terms of computational characteristics rather than the needs of the end user. In order to accommodate these real needs, the VS2 batch system is run as one of the users of VM during the working day. Programmers who normally work in VS2 are given facilities to submit jobs to that system. Relatively short jobs are run to completion as received. Longer jobs are held for execution until evening hours.

The facilities of VS2 operated under VM during the day are identical to those of VS2 operating by itself in the evening. However, the performance is significantly degraded because VS2 competes with seventy or more other users of the VM system and because of the double overhead of one system running under the control of another. Recently IBM has made changes to VM and to another version of the batch processing system, VS1, to reduce this double overhead.

Timing tests conducted during the quarter showed that a job stream executed in less than half the elapsed time under the VM/VS1 combination than it had under VM/VS2. As a result, work is now under way to replace the VS2 system with VS1 both for VM operations and for evening batch processing. The replacement will require few, if any, user programming changes. Most of the work will be in preparing the new system and training operations personnel.

SOLID STATE  
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 May through 31 July 1975 on Solid State Research projects funded primarily by the Air Force. The Solid State Research Report for the same period describes this work of Division 8 in more detail.

A. L. McWhorter  
Head, Division 8  
I. Melngailis  
Associate Head

DIVISION 8 REPORTS  
ON ADVANCED ELECTRONIC TECHNOLOGY

15 May through 15 August 1975

PUBLISHED REPORTS

Journal Articles

JA No.

4173	Apparent Mobility Enhancement in Inhomogeneous Crystals	C. M. Wolfe G. E. Stillman	Chapter in <u>Semiconductors and Semimetals</u> , Vol. 10, "Transport Phenomena," R. K. Willardson and A. C. Beers, Eds. (Academic Press, New York, 1975), p. 175
4393	Unified Model of the Insulator-Metal Transition in $Ti_2O_3$ and the High-Temperature Transitions in $V_2O_3$	H. J. Zeiger	Phys. Rev. B <u>11</u> , 5132 (1975)
4419	Tunable Semiconductor Diode Lasers and Applications	I. Melngailis A. Mooradian	Chapter in <u>Laser Applications to Optics and Spectroscopy</u> , S. Jacobs, M. Sargent, III, J. F. Scott, and M. O. Scully, Eds. (Addison-Wesley, Reading, Massachusetts, 1975), p. 1
4452	Planar InSb Photodiodes Fabricated by Be and Mg Ion Implantation	C. E. Hurwitz J. P. Donnelly	Solid-State Electron. <u>18</u> , 753 (1975)
4459	Screening by Fixed Charges in Compensated Semiconductors	D. M. Larsen	Phys. Rev. B <u>11</u> , 3904 (1975)
4460	Evidence for Localized Excitations in MgO from Electron Energy-Loss Spectroscopy	V. E. Henrich G. Dresselhaus	Solid State Commun. <u>16</u> , 1117 (1975)
4473	Low-Threshold cw $LiNdP_4O_{12}$ Laser	S. R. Chinn H. Y-P. Hong	Appl. Phys. Lett. <u>26</u> , 649 (1975)
4476	Efficient InSb Laser with Resonant Longitudinal Optical Pumping	N. Menyuk A. S. Pine A. Mooradian	IEEE J. Quantum Electron. <u>QE-11</u> , 477 (1975)
4481	Observation of a Very Narrow Surface Resonance on Single-Crystal Aluminum	V. E. Henrich	Surf. Sci. <u>49</u> , 675 (1975)
4498	PbS MIS Devices for Charge-Coupled Infrared Imaging Applications	F. J. Leonberger A. L. McWhorter T. C. Harman	Appl. Phys. Lett. <u>26</u> , 704 (1975)



JA No.

- |      |  |  |  |
|------|--|--|--|
| 4502 | Crystal Structure of NdLiP <sub>4</sub> O <sub>12</sub>                                    | H. Y-P. Hong   | Mater. Res. Bull. <u>10</u> , 635 (1975) |
| 4503 | Integrated GaAs-AlGaAs Double-Heterostructure Lasers                                       | C. E. Hurwitz<br>J. A. Rossi<br>J. J. Hsieh<br>C. M. Wolfe | Appl. Phys. Lett. <u>27</u> , 241 (1975) |
| 4506 | Silicon- and Selenium-Ion-Implanted GaAs Reproducibly Annealed at Temperatures Up to 950°C | J. P. Donnelly<br>W. T. Lindley<br>C. E. Hurwitz           | Appl. Phys. Lett. <u>27</u> , 41 (1975)  |
| 4511 | Crystallization of Amorphous Silicon Films by Nd:YAG Laser Heating                         | J. C. C. Fan<br>H. J. Zeiger                               | Appl. Phys. Lett. <u>27</u> , 224 (1975) |

Meeting SpeechesMS No.

- |      |   |  |  |
|------|---|--|--|
| 3831 | GaAs Electroabsorption Avalanche Photodiode Detectors                             | G. E. Stillman<br>C. M. Wolfe<br>J. A. Rossi<br>J. L. Ryan | In <u>Gallium Arsenide and Related Compounds</u> (Institute of Physics, London, 1975), p. 210  |
| 3889 | The Gain Profile and Time-Delay Effects in External-Cavity-Controlled GaAs Lasers | J. A. Rossi<br>J. J. Hsieh<br>J. Heckscher                 | IEEE J. Quantum Electron. <u>QE-11</u> , 538 (1975)  |
| 3972 | Structure and Properties of Magnetic Materials                                    | J. B. Goodenough   | Proceedings of Symposium on Applied Crystal Chemistry and Physics, <u>Transactions of the American Crystallographic Association</u> , Vol. 11 (American Crystallographic Association, New York, 1975), p. 15 |
| 3984 | Solar Energy Cooling with Zeolites  | D. I. Tchernev   | Proceedings of NSF/RANN Workshop on Solar Collectors, New York, 21-23 November 1974, p. 262  |

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## UNPUBLISHED REPORTS

Journal ArticlesJA No.

- |      |   |   |                                       |
|------|---|---|---------------------------------------|
| 4339 | Many-Body Treatment of Pressure Shifts Associated with Collisional Broadening | R. W. Davies                                | Accepted by Phys. Rev.                |
| 4469 | Low-Threshold, Transversely-Excited NdP <sub>5</sub> O <sub>14</sub> Laser    | S. R. Chinn<br>J. W. Pierce<br>H. Heckscher | Accepted by IEEE J. Quantum Electron. |

Meeting Speeches\*

MS No.

3937A	Transparent Heat Mirrors for Solar-Energy Collection	J. C. C. Fan	} 2nd Annual Symposium on Solar Energy and Its Applications, N.E. Chapter American Vacuum Society, Burlington, Massachusetts, 5-6 June 1975
4060	Photoelectrolysis of Water by Solar Energy	D. I. Tchernev	
3937B	Transparent Heat Mirrors for Solar-Energy Collection	J. C. C. Fan	Workshop - Spectrally Selective Surfaces for Photothermal Solar Energy Conversion, Minneapolis (sponsored by ERDA/NSF-RANN), 17-19 July 1975
3960	Low-Threshold, Transversely-Excited NdP <sub>5</sub> O <sub>14</sub> Laser	S. R. Chinn J. W. Pierce H. Heckscher	} 1975 IEEE/OSA Conference on Laser Engineering and Applications, Washington, D. C. 28-30 May 1975
3961	Optically Pumped Infrared Transfer Lasers	T. F. Deutsch H. Kildal	
3965	Planar HgCdTe Photodiodes for Wideband Heterodyne Detection at 10.6 $\mu$ m	D. L. Spears I. Melngailis T. C. Harman	
4070	Applications of Tunable Infrared Lasers	P. L. Kelley	
4076	Frequency Stabilization and Absolute Frequency Measurements of a cw HF/DF Laser	R. S. Eng D. L. Spears	
4077	Optically Pumped 15.90 $\mu$ m SF <sub>6</sub> Laser	H. R. Fetterman H. R. Schlossberg <sup>†</sup> W. E. Barch	
3987C	GHz Bandwidth HgCdTe Photodiodes for Heterodyne Detection in the 4 to 12 $\mu$ m Region	D. L. Spears	Seminar, NASA Goddard Space Flight Center, Greenbelt, Maryland, 27 May 1975
3993	Tunable Coherent Light Sources	A. Mooradian	Conference "LASERS 75," Munich, Germany, 24 June 1975
4041	Lineshape Asymmetries in Light Scattering from Opaque Materials	A. S. Pine G. Dresselhaus	} Third International Conference on Light Scattering in Solids, Campinas, SP, Brazil, 25-30 July 1975
4099	Transient Response of an External Cavity 12 $\mu$ m Spin-Flip Laser	S. R. J. Brueck	

\* Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

<sup>†</sup> Author not at Lincoln Laboratory.

MS No.

4045	Energy-Loss Spectroscopy of Surface States on Titanium and Vanadium Oxides	V. E. Henrich H. J. Zeiger G. Dresselhaus	35th Annual Conference on Physical Electronics, Pennsylvania State University, University Park, Pennsylvania, 2-4 June 1975
4046	PbS MIS Devices for Charge-Coupled Infrared Imaging Applications	I. Melngailis	Infrared Detector Materials Conference, Paris, France, 26-28 May 1975
4057	Integrated GaAs-AlGaAs Double-Heterostructure Lasers	C. E. Hurwitz J. A. Rossi J. J. Hsieh C. M. Wolfe	1975 Device Research Conference, Ottawa, Canada, 24-26 June 1975
4058	Low-Loss High Purity GaAs Waveguides for Monolithic Integrated Optical Circuits at GaAs Laser Wavelengths	G. E. Stillman C. M. Wolfe J. A. Rossi H. Heckscher	
4063	Reproducible, High Carrier Concentration Implantations of Selenium and Silicon into GaAs	J. P. Donnelly W. T. Lindley C. E. Hurwitz	
4059	Photoelectrolysis of Water on Semiconducting Surfaces	D. I. Tchernev	VIII International Conference on Photochemistry, University of Alberta, Edmonton, Canada, 7-13 August 1975
4067A, B, C	Tunable Infrared Lasers	A. Mooradian	IV Vavilov Conference on Nonlinear Optics, Novosibirsk, USSR, 12-14 June 1975; Laser Spectroscopy Conference, Megeve, France, 23-27 June 1975; Molecular Spectroscopy Conference, Erice, Italy, 28 June - 5 July 1975; Scottish University Summer School in Physics, Edinburgh, Scotland, 4-8 August 1975
4074	Application of Nonlinear Optical and High-Speed Heterodyne Techniques to Frequency Calibration in the Infrared	R. S. Eng	Thirtieth Symposium on Molecular Structure and Spectroscopy, Ohio State University, Columbus, 16-21 June 1975
4077A	Optically Pumped 15.90 $\mu\text{m}$ SF <sub>6</sub> Laser	H. R. Fetterman H. R. Schlossberg* W. E. Barch	1975 International IEEE/APS Symposium and USNC/URSI Meeting, Urbana, Illinois, 4 June 1975

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\* Author not at Lincoln Laboratory.

## SOLID STATE DIVISION 8

### I. SOLID STATE DEVICE RESEARCH

Low-loss high-purity GaAs waveguides for monolithic integrated optical circuits have been fabricated and characterized. Attenuation measurements of waveguides at wavelengths near the GaAs absorption edge show that losses of less than  $1.5 \text{ cm}^{-1}$  at wavelengths  $>0.905 \text{ }\mu\text{m}$  can be obtained in material with  $(N_D + N_A) \leq 2 \times 10^{15} \text{ cm}^{-3}$ .

High-resolution heterodyne absorption spectra of ethylene have been determined by using the wide bandwidth and high sensitivity of recently developed HgCdTe photodiodes. With about 1 mW of  $\text{CO}_2$  laser local-oscillator power, the signal-to-noise ratio in the 0.3- to 0.5-GHz region was better than 80:1.

Several improvements in the growth and fabrication processes used for PbSnTe double-heterostructure diode lasers have been achieved. It is anticipated that these improvements should give sufficient reproducibility to evaluate the intrinsic behavior of these devices.

$\text{CO}_2$  laser-pumped CW laser emission from high-quality PbSnTe crystals is reported. The optically pumped PbSnTe laser devices, which should be useful in the field of high-resolution spectroscopy, operate continuously from  $16.04 \text{ }\mu\text{m}$  at liquid-helium temperature to  $15 \text{ }\mu\text{m}$  at  $\sim 25 \text{ K}$ .

### II. QUANTUM ELECTRONICS

Neodymium pentaphosphate ( $\text{NdP}_5\text{O}_{14}$ ) has been operated quasi-CW at room temperature by transverse pumping with a laser diode emitting at  $0.8 \text{ }\mu\text{m}$ . The observed maximum optical-to-optical power conversion efficiency was 7.5 percent, and the pumping threshold was 12.4 mW.

Continuous operation has been obtained in LiNd-metaphosphate ( $\text{LiNdP}_4\text{O}_{12}$ ) using a  $0.58\text{-}\mu\text{m}$  laser pump. A platelet  $158 \text{ }\mu\text{m}$  thick and approximate cross section  $0.5 \times 0.5 \text{ mm}^2$  was pumped normal to the platelet face, with the lasing cavity arranged collinearly to the pumping direction. The threshold power was observed to be  $360 \text{ }\mu\text{W}$ . For 1-mW quasi-CW operation (20 percent duty cycle), a power conversion efficiency of 18 percent was found.

A pulsed  $\text{CO}_2$ -pumped InSb spin-flip Raman laser has been operated with an external cavity in which the output frequency is governed to a large extent by the Fabry-Perot modes of the resonant output coupler. An output spectral width of  $0.027 \pm 0.003 \text{ cm}^{-1}$  has been obtained.

Optically pumped, collisional transfer, laser action has been achieved in  $\text{C}_2\text{H}_2$ ,  $\text{CS}_2$ , and  $\text{SiH}_4$ . Resonant collisional transfer excites the  $0100^0_0$  level in  $\text{C}_2\text{H}_2$ , a mode which is not connected to the ground state by a vibration dipole, while in  $\text{CS}_2$  the vibrational transfer is to the  $10^0_1$  combination band. In  $\text{SiH}_4$ , in which laser operation is reported for the first time, laser output is observed at pressures up to 35 Torr.

The CW submillimeter heterodyne detection system has been extended to pulsed operation. The 8th harmonic of a klystron was mixed with pulsed far-infrared radiation from a methyl fluoride laser in a small-area GaAs Schottky diode. The  $\text{CH}_3\text{F}$  laser at  $496 \text{ }\mu\text{m}$ , which was pumped by a  $\text{CO}_2$  TEA laser, had a measured linewidth of less than 5 MHz.



### III. MATERIALS RESEARCH

Although the internal quantum efficiency is close to 100 percent for photogalvanic cells in which a  $\text{TiO}_2$  or  $\text{SrTiO}_3$  anode is shorted to a platinized-Pt cathode, it has been found that because of insufficient anode band bending the maximum efficiency of photoelectrolysis with such cells is about 10 percent. For effective utilization of solar energy to generate  $\text{H}_2$  fuel by means of photoelectrolysis, the ideal anode material should have an electron affinity no greater than  $\sim 3.5$  eV in order to achieve sufficient band bending (in addition to an energy gap  $\sim 1.8$  eV).

A flux method has been used to grow crystals of  $\text{KNdP}_4\text{O}_{12}$ , a new, acentric, high-Nd-concentration material for use in very small, low-threshold lasers. The compound's lack of inversion symmetry may allow second-order nonlinear optical processes (e.g., second-harmonic generation) as well as linear electro-optic modulation to be carried out directly in the laser crystals.

A liquid-phase epitaxial technique has been developed for the growth of very thin GaAs layers at rates exceeding  $100 \mu\text{m}/\text{min}$ . By pushing a supercooled growth solution over the substrate wafer at the rate of 10 to 20 cm/sec, a reproducible thickness of about  $0.1 \mu\text{m}$  has been achieved for the active layers of double-heterostructure  $\text{GaAs-Ga}_{1-x}\text{Al}_x\text{As}$  diode lasers.

### IV. MICROELECTRONICS

The fabrication of a two-phase, buried-channel,  $100 \times 1$  charge-coupled imaging array has been completed. The device utilizes an ion-implanted barrier under alternate gates to create true two-phase operation. The channel is formed by ion-implanting phosphorous atoms, and both the first- and second-level gates are polysilicon to insure that the device has maximum sensitivity to frontside illumination. The potential well under the storage (first-level) gates at zero bias has been found to be 5.3 to 5.5 V higher than that under the transfer (second-level) gates, which agrees well with the calculated value of 5.8 V. Measurements of transfer inefficiencies have been made at a clock frequency of 1 MHz and are  $1.3 \pm 0.5 \times 10^{-4}$ . Lower transfer inefficiencies are expected when device processing techniques which reduce the bulk trap density in the finished devices are fully developed.

Varactor diodes are being fabricated of sufficiently high quality to be used in a  $K_a$ -band parametric amplifier for a LES-8/9 ground-station receiver. Current efforts in this program have been concentrated on developing a packaging network which provides contact between the diode and the waveguide circuit. Two packaging schemes are being evaluated to determine how each meets the electrical and mechanical requirements of the network. One approach is based on the use of a single capacitive standoff which is connected to the device by an inductive ribbon. The other approach utilizes an inductive loop and capacitive pad which are fabricated as part of the device, and these components are then connected to an external capacitive post.



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  <p>This Quarterly Technical Summary covers the period 1 May through 31 July 1975. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.</p>		